IN THE SPECIFICATION:

Please amend paragraph number **[0011]** as follows:

[0011] In United States Patent 5,620,927 of Lee, a template with an array of through-holes is placed on the workpiece and solder balls are introduced into the holes by rolling the solder balls across the workpiece surface. The apparatus may be installed on a tilt table to encourage filling of all holes. In United States Patent 4,871,110 of Fukasawa et al., a template having an array of holes is placed on a ball holder with a like array of smaller holes to which vacuum is applied and over which solder balls are rolled. After the array is filled with solder balls, the template and ball holder with balls are removed and the exposed ends of the balls attached to a substrate by ~~e.g.~~ e.g., reflow. The template and ball holder are then pulled from the substrate, leaving a ball-grid-array ready for attachment to another substrate or workpiece. A vacuum system is required, and there is no easy way to replace a solder ball onto a bond pad to which a ball did not become attached (*i.e.*, missing ball).

Please amend paragraph number **[0020]** as follows:

BRIEF SUMMARY OF THE INVENTION

[0020] The invention comprises apparatus and methods for rapidly, accurately, and reliably placing an array of conductive spheres such as solder balls on conductive sites, ~~e.g.~~ e.g., bond pads, on a substrate. The substrate may be a circuit board of any composition, ~~e.g.~~ e.g., BT resin, or may be a silicon wafer or even a single semiconductor die such as an "IC ~~chip".~~ chip." The conductive sites on the substrate may comprise bond pads which include those which project from the substrate and those which are recessed into the substrate surface. Projecting bond pads require a pre-application of flux or other sticky substance by which the spheres cling to the bond pads. Use of flux or sticky substance may not necessarily be required with recessed bond pads.

Please amend paragraph number **[0021]** as follows:

[0021] The apparatus includes a stencil plate or screen overlying the substrate, wherein the stencil plate is parallel to and slightly spaced from the substrate. The stencil plate has an array of through-holes corresponding to a desired placement pattern of conductive spheres on the substrate. The invention also includes ball supply apparatus for providing conductive spheres to the stencil plate, wherein all through-holes in the stencil plate are filled with one, and only one, sphere. Spheres placed into the through-holes of the stencil plate drop by gravity to the substrate for retention by pre-applied flux or by depressed bond pads. Each through-hole is slightly larger than a sphere and constrains a sphere on the substrate until the substrate and stencil plate are further separated ~~e.g.~~ e.g., for solder reflow. The stencil plate thickness and proximity to the substrate prevent more than one ball from entering each through-hole of the stencil plate.

Please amend paragraph number **[0023]** as follows:

[0023] In a second embodiment, a sphere supply apparatus includes a shuttle plate with the same through-hole pattern as the stencil plate. The shuttle plate closely overlies the stencil plate and is reversibly movable between a first position wherein its through-hole pattern is aligned with the pattern of the stencil plate and a second position wherein the through-hole patterns are non-aligned. In the first position, spheres may drop from the shuttle plate through-holes into the stencil plate through-holes. In the latter position, spheres are prevented from entering the through-holes of the stencil plate. The through-holes of the shuttle plate may be fed from an overlying open bottom reservoir, which may be fixed to the shuttle plate or fixed in position. The linear movement of the shuttle plate is less than the inter-sphere distance, ~~i.e.~~ i.e., pitch, and is generally equal to about one-half of the pitch.

Please amend paragraph number **[0038]** as follows:

DETAILED DESCRIPTION OF THE INVENTION

[0038] The invention comprises an improved method and apparatus for placing a plurality of conductive spheres 12, such as preformed solder balls or germanium balls, on conductive sites 14 on a surface 16 of a substrate 20. The term "substrate" is used in a broad

generic sense herein to include any semiconductor device including a wafer or a packaged or unpackaged bare die, as well as traditional substrates including circuitized boards such as printed circuit boards (PCBs). The method of the invention may be applied to the placement of conductive spheres 12 on any conductive site 14, whether the site, ~~e.g.~~ e.g., a bond pad, projects from the substrate 20 or is recessed therein. The terms "conductive site" and "bond pad" are used interchangeably herein to denote any conductive site 14 at which a conductive sphere 12 is to be placed.

Please amend paragraph number **[0039]** as follows:

[0039] One embodiment of the sphere placement apparatus 10 and the placement method used therewith are illustrated in drawing FIGS. ~~1 through 4.~~ 1-4.

Please amend paragraph number **[0040]** as follows:

[0040] As depicted in drawing FIG. 1, a sphere placement apparatus 10 for placing a plurality of conductive spheres 12 on a substrate 20 comprises a stencil plate or screen 30 and a sphere supply apparatus 50/50A. The substrate 20 is shown with a pattern 22 of conductive sites or bond pads 14 with an interpad pitch 18, wherein the pattern 22, in this example, includes all of the bond pads. The substrate 20 is shown with exemplary registry markers 24 by which the stencil plate 30 and ~~substrate~~ substrate 20 may be accurately aligned to each other. The various components of the invention may be aligned using a mechanical or pattern recognition alignment, or any other type of accurate alignment apparatus as known in the art.

Please amend paragraph number **[0042]** as follows:

[0042] The stencil plate 30 has a thickness 40 which is configured and positioned for holding conductive spheres 12 on bond pads 14, such that a sphere supply apparatus 50 moving across the stencil ~~plate~~ plate 30 does not intercept the placed spheres, while preventing more than one sphere from entering each through-hole 34.

Please amend paragraph number **[0045]** as follows:

[0045] Referring to drawing FIG. 7, illustrated is a straight through-hole 34 of a stencil plate 30. As depicted in drawing FIG. 8, the through-hole 34 may have a beveled upper edge 72 which enhances movement of conductive spheres 12 into the through-hole 34.

Please amend paragraph number **[0046]** as follows:

[0046] The sphere placement apparatus 10 includes a sphere supply apparatus 50 which in this embodiment is a hopper 50A having a lower opening 44 (FIG. 4) by which conductive spheres 12 may drop into through-holes 34 of the stencil plate 30 as the ~~hopper~~ hopper 50A is moved across the upper surface 38 of the stencil plate 30. The hopper 50A has inner walls 46 which contain and feed conductive spheres 12 to the stencil plate 30.

Please amend paragraph number **[0047]** as follows:

[0047] The lower opening 44 has a width 48 equivalent to about two (2) to about ten (10) sphere diameters 28. Thus, for conductive spheres 12 having a diameter 28 of 1.0 mm, the lower ~~opening~~ opening 44 may have a width 48 of about 0.2 cm. to about 1.0 cm.

Please amend paragraph number **[0050]** as follows:

[0050] In the drawings of FIGS. 1-6, the bond pads 14 of substrate 20 are pictured as projecting from the ~~substrate.~~ substrate 20. The sphere placement apparatus 10 may be used for placing spheres onto recessed bond pads 14, as depicted in drawing FIG. 9. Depending on the sphere diameter 28 and the recess depth 74 of the bond pads 14, the stencil plate thickness 40 may need to be adjusted to achieve a sufficient plate-to-pad gap 56.

Please amend paragraph number **[0052]** as follows:

[0052] Another embodiment of the sphere placement apparatus 10 is shown in drawing FIGS. 11-13. The substrate 20 and stencil plate 30 are shown as being identical to those already described above. However, the sphere supply apparatus 50 comprises a shuttle plate 80 which underlies a sphere reservoir 90. ~~Reservoir~~Sphere reservoir 90 may be attached to the shuttle

plate 80, or may comprise a separate structure. Shuttle plate 80 has an upper surface 88 and a parallel lower surface 92, with a third pattern 82 of through-holes 84. The third pattern 82 is substantially the same as through-hole pattern 32, although through-holes 84 may be of somewhat greater diameter 86 than the diameter 36 of through-holes 34. The shuttle plate 80 and sphere reservoir 90 may be configured to reversibly move a short distance in direction 94, ~~i.e.~~ i.e., roughly one-half of the interpad pitch 18. Thus, the shuttle plate 80 moves from a position where its ~~through-hole~~ third pattern 82 is non-aligned with the through-hole pattern 32 (see FIG. 12) to a position where it is aligned therewith (see FIG. 13) for dropping the conductive spheres 12 into through-holes 34 and thus onto the bond pads 14.

Please amend paragraph number **[0053]** as follows:

[0053] In another embodiment of the shuttle plate 80 and sphere reservoir 90, they are not connected. The sphere reservoir 90 may be kept in one position while the shuttle plate 80 moves past it for filling the through-holes 84.

Please amend paragraph number **[0054]** as follows:

[0054] Turning now to the method of using sphere placement apparatus 10 for placing conductive spheres 12 on a substrate 20, we examine drawing FIGS. ~~2 through 6~~ 2-6 in sequence.

Please amend paragraph number **[0059]** as follows:

[0059] Upon filling of all through-holes 34 with conductive spheres 12, the substrate 20 and/or the stencil plate 30 with hopper 50A are moved in direction 70, separating the ~~substrate~~ substrate 20 as shown in drawing FIG. 5 for further manufacturing steps. The next step is typically one of heating the substrate 20 and conductive spheres 12 to cause a reflow of the solder spheres, resulting in spheres fixed to the bond pads 14 as shown in drawing FIG. 6. Where the conductive spheres are not solder, but comprise a metal such as germanium, the sphere placing method may begin with solder being placed on each bond pad 14, fluxing of the solder surface, and then placement of the conductive spheres 12.

Please amend paragraph number **[0060]** as follows:

[0060] The placement method for the embodiment of drawing FIGS. 11-13 is similar to that of drawing FIGS. 1-4. The steps of pre-applying a layer 52 of flux or sticky material to the bond pads 14, and aligning of the stencil plate 30 with the substrate 20 are the same or similar. Once the prefluxed substrate 20 is properly installed in the apparatus, the shuttle plate 80 and sphere reservoir 90 are moved from a non-aligned position to an aligned position, whereby conductive spheres 12 fill the through-holes 84 of the shuttle ~~plate~~ plate 80 and, upon reaching the aligned position (FIG. 13), are dropped into the through-holes 34 of the stencil plate 30 and onto the prefluxed bond pads 14. The substrate 20 may be then separated from the stencil plate 30 and the conductive spheres 12 fixed by reflow to the ~~substrate.~~ substrate 20.